MAY 1918 BULLETIN NO. 1

DEPARTMENT OF TRADE AND COMMERCE
DOMINION GRAIN RESEARCH LABORATORY

Report

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Trial Shipment of Bulk Wheat from Vancouver via the Panama Canal

To the

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REPORT OF TRIAL SHIPMENT OF BULK WHEAT FROM VANCOUVER VIA THE PANAMA CANAL TO THE UNITED KINGDOM

F. J. BIRCHARD and A. W. ALCOCK

Since the opening of the Panama Canal the possibility of shipping bulk wheat from Canada to Europe by this route has been discussed a great deal. It was the opinion of many that the conditions to which the grain would be subjected in the tropics would be found too severe for Canadian grain, and that there would be a grave danger of cargoes arriving at their destination in a heating condition. It was decided, therefore, by the Department of Trade and Commerce, when arrangements were made in the fall of 1917 for sending a trial shipment of wheat from Vancouver, to have the laboratory make as thorough an investigation as possible as to the feasibility of the route. In order that a complete record of the temperature changes which occurred in the grain might be secured, the holds of the ship were equipped with electrical thermometers and a representative of the laboratory accompanied the shipment to make the observations and to examine the cargo when it was discharged. Similar experimental work had previously been done by the United States Department of Agriculture in connection with the shipment of corn to Europe, and valuable results, which were found of great use in setting the standards for corn were obtained. From the present investigation it was hoped to secure definite information as to the temperatures which grain would have to stand when carried by this route, and to determine what precautions should be taken to minimize the danger of heating in the event of future shipments being made.

The wheat for this shipment was collected from various points in western Alberta. In Calgary an average sample from each car was tested for moisture and graded by the Inspection Department, and in order to confirm the results of these moisture tests, further samples were taken in Vancouver when the cars were unloaded. These latter samples were sent in air-tight containers to the laboratory, where they were tested on an electrically heated Brown-Duvel apparatus. All the wheat in this shipment was "straight grade," *i.e.* it did not, in the inspector's opinion, contain excessive moisture and was in every way sound and fit for warehousing. But although the wheat felt very dry and hard it was found that some of the cars contained relatively high percentages of moisture, and it was decided to keep such wheat separate from the rest of the parcel to which it really belonged. Three out of the four parcels were thus divided in the elevator into two portions, these two parts being subsequently kept separate in the holds of the ship. By this means it was thought that some additional information might possibly be obtained with regard to the carrying qualities of wheat containing different percentages of moisture but otherwise similar in every way. Before being binned in the elevator any carload lots containing more than one per cent of dockage were passed over the cleaners.

The grade, weight and percentage of moisture in the different parcels are given in Table 1.

TABLE 1.—Grade, moisture content and weight of the different parcels of wheat.

Parcel.	Grade.	Average Moisture Content.	Weight in Bushels.
		Per cent.	
F	1 Hard (Highest Moisture)	15	5·907
B	1 Hard	14	9·258
A	No. 1 Northern (Highest Moisture)	15	9·619
E	No. 1 Northern	13·8	42·482
Y	No. 2 Northern (Highest Moisture)	15	4·062
C	No. 2 Northern	13·2	14·559
D	No. 3 Northern	13·6	13·322
			99·209

The vessel which carried this cargo was the SS. *War Viceroy,* a new steel ship which had just been built on the Pacific Coast. The grain was placed in two of the lower holds, all of it being below the water line when the vessel was fully loaded.

Diagram 1 shows the disposal of the wheat in the vessel.

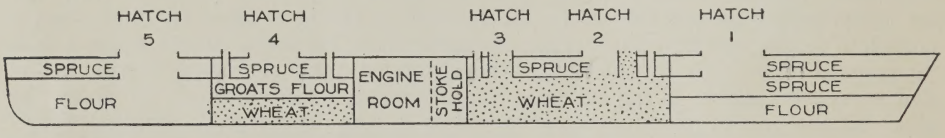

Fig. 1. Diagram showing section of vessel and illustrating the general arrangement of the cargo.

The dimensions of the forward hold into which the main bulk of the wheat was loaded were roughly 100′ x 50′ x 18′ 6″. It was prepared for the reception of the wheat by flooring with 3″ boards, and lining the sides to a height of 2′ 6″ with the same material. Above this lining the wheat was in direct contact with the ship's side. A substantial shifting board was erected fore and aft down the centre to the full height of the hold, and a wooden partition was built at the after end so as to allow an air space of 12″ between it and the iron bulkhead which separated the hold from the fire room.

The after hold was similarly floored and lined and in this case a wooden partition was placed 9″ from the engine room bulkhead. It was unnecessary to build a shifting board in this hold as it was divided to a sufficient height by the propeller shaft tunnel. All the lumber used in the holds had been thoroughly dried.

Each parcel of wheat after being delivered to the vessel was trimmed so that its surface was practically horizontal, and then separating cloths were spread over the top to divide it from the succeeding layer. During the loading average samples of each parcel were again taken for moisture test. It was decided to keep the grain which had been segregated on account of its high moisture content away from the stokehold bulkhead, where the greatest heat might be expected, and with this object a quantity of the dryer grain was placed between the partition near the stokehold and the high moisture 1 Northern, while the high moisture 1 Hard was loaded into the forward end of the hold.

Throughout the experiment the necessity of avoiding such precautionary measures as would be impossible under ordinary trade conditions was not lost sight of, but it would have been an unnecessarily severe experiment had the wheat most liable to damage been placed in the warmest part of the hold. In some seasons fairly large parcels of straight grade wheat might be found containing as high as 15 per cent of moisture but this would be exceptional. In the present case had no separation on account of moisture been made, all the wheat of each grade would have been thoroughly mixed by the time it had been trimmed, and the average moisture content would have been only a little more than the average in the lower moisture parcels. This was because the high moisture parcels were relatively small in quantity.

Figures Nos. 2-5 show how the parcels of grain were loaded into the holds.

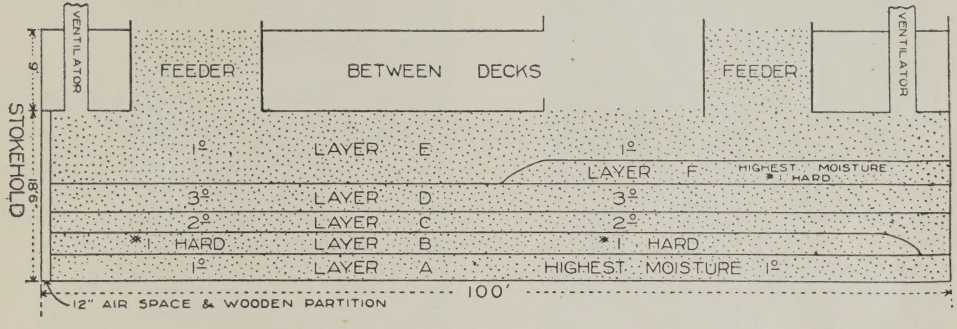

Fig. 2. Section fore and aft through forward hold showing arrangement of the different layers of wheat.

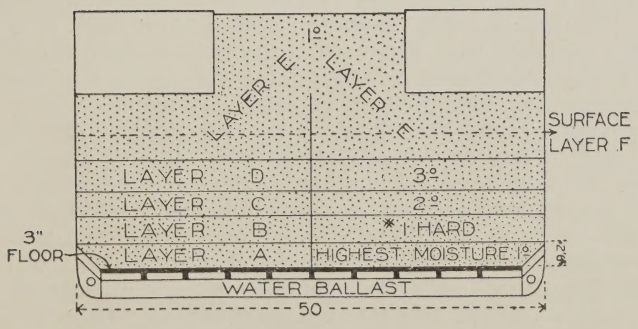

Fig. 3. Section through hatch 2.

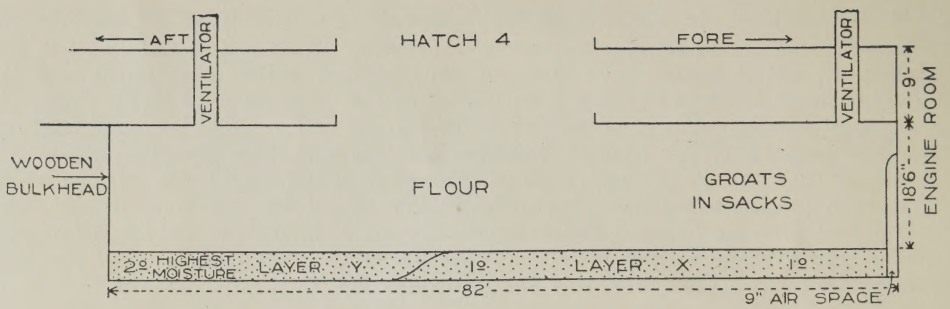

Fig. 4. Section fore and aft through afterhold.

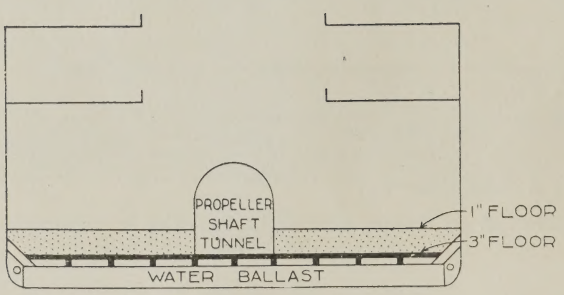

Fig. 5. Section through hatch 4.

The electrical resistance thermometers which were placed in the holds, had been previously used in storage tests on a large scale in elevator bins, and had been found to give very satisfactory results. With this apparatus the measurement of temperature depends upon the well known fact that the electrical resistance of a metallic wire varies with the temperature, the principle of the Wheatstone Bridge being used in determining the changes in resistance.

The thermometers were tied on to long steel cables with marlin, friction tape being wrapped round each knot to prevent it from slipping. They were usually arranged in sets of thirteen along each cable so that a distance of 5′ separated one thermometer from another. After each parcel of wheat had been trimmed and just before spreading the separating cloths, the line of thermometers for that particular layer was dropped down one of the ventilators leading into the hold, stretched out and embedded in the grain to a depth of 6″ to 12″. All the lead wires from the line of thermometers passed up through the ventilator and their ends were soldered to a thirteen point switch. This switch was screwed into a hard wood box which was lashed to the outside of the ventilator and afterwards covered with tarpaulin for protection against the weather.* When the temperatures were to be measured, this cover was taken off, the door of the box opened and the switch connected with the temperature indicator and battery.

*See Appendix 1.

Fig. 6 shows one of the covered boxes, and Fig. 7 is a photograph of a box containing two switches with the indicator and battery connected ready for taking temperatures, while Figs. 8-11 show the positions of the thermometers in the grain.

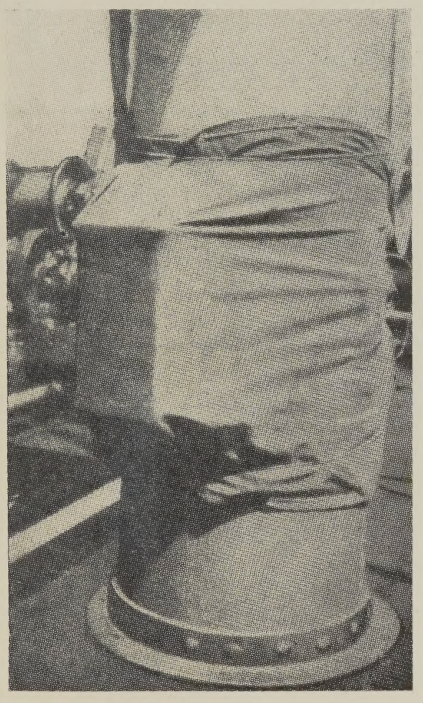

Fig. 6. Illustration showing one of the covered boxes.

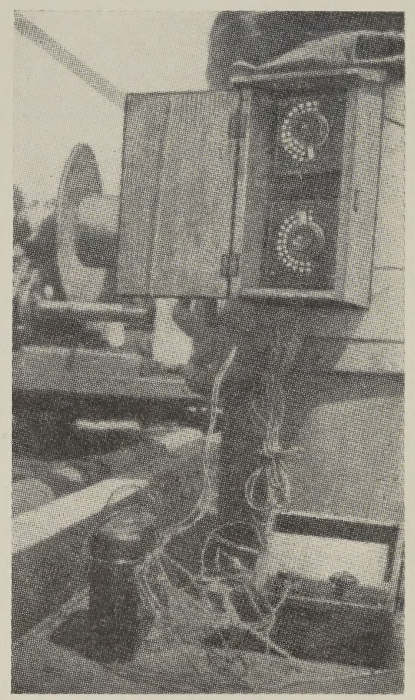

Fig. 7. Illustration showing box containing two switches.

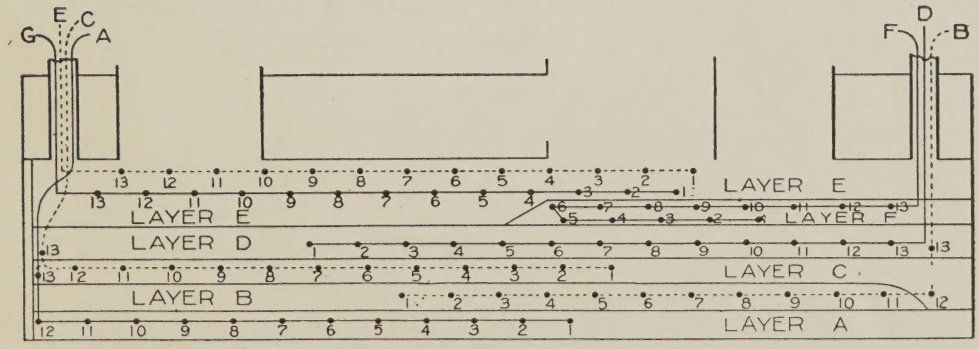

Fig. 8. Diagram showing arrangement of thermometers in forward hold, those on starboard side being indicated by continuous lines and those on port side by dotted lies.

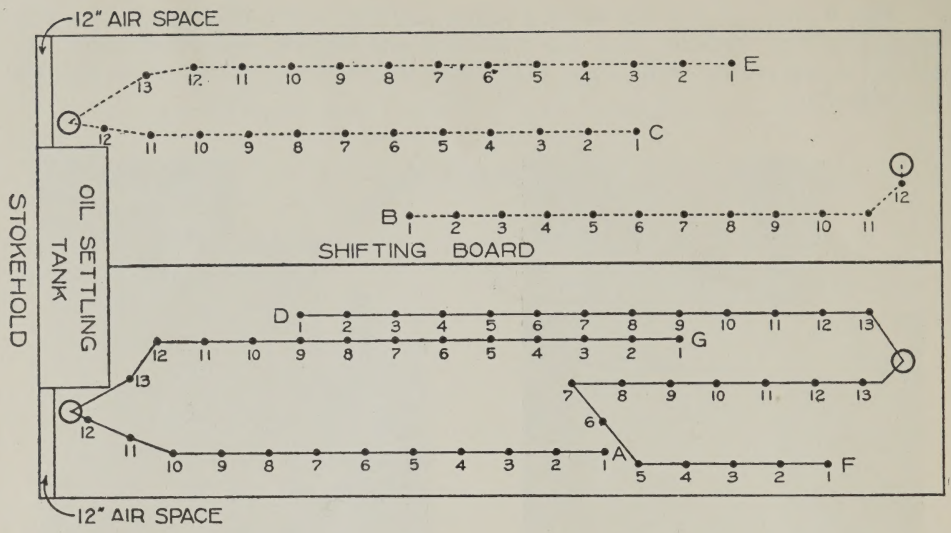

Fig. 9. Plan of forward hold showing thermometers.

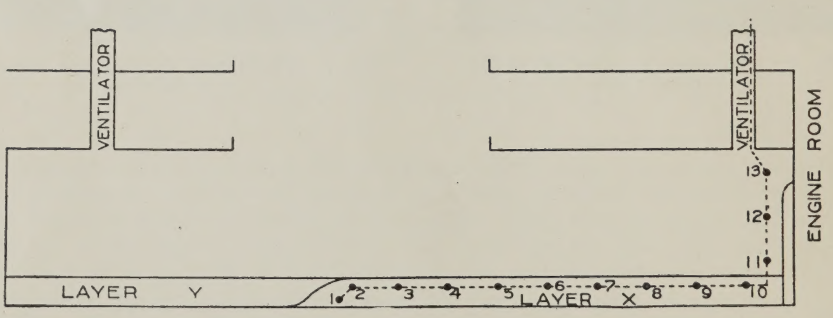

Fig. 10. Diagram showing arrangement of thermometers in afterhold.

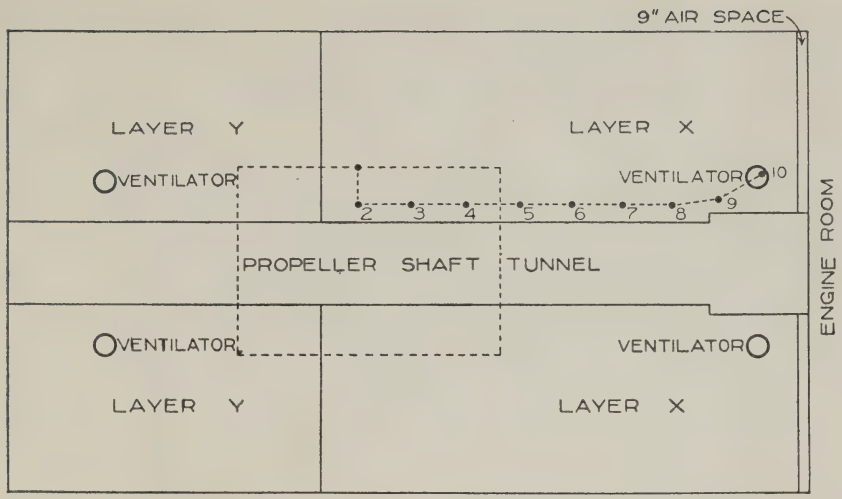

Fig. 11. Plan of afterhold showing arrangement of thermometers.

The loading of the grain, owing to delays from various causes, occupied five days and was concluded on November 13th, but it was not until December 3rd, after taking on further cargo at Portland, Oregon, that the ship sailed for the Panama. During the voyage between Portland, Oregon, and Norfolk, Virginia, daily records were kept of the maximum temperature of the air, and of the readings of wet and dry bulb thermometers, while the sea water temperatures were obtained from the Engineer's Department. The complete record is not given in Table 2 but the data reported are sufficient to show what changes in temperature were experienced. The humidity record has been omitted altogether, as this factor is considered to be of little, if any, importance. It is sufficient to say that the humidity of the air was usually very high, often reaching the saturation point after sunset. On the arrival of the ship at Norfolk on January 10th, the sea water and air temperatures were about 32° F, and the weather remained cold until the voyage was resumed on January 26th. While crossing the Atlantic no observations were made on account of the very rough weather experienced.

TABLE 2.—Record of sea water and air temperatures during voyage from Portland, Ore., to Norfolk, Va.

Date.	Location.	Temperature Sea Water. Degrees F.	Temperature Air. Degrees F.
November 27, 1917..	Portland, Oregon	.....	.....
December 5, 1917..	Oregon Coast	.....	55
" 7, 1917..	Californian Coast	.....	59
" 8, 1917..	Californian Coast	.....	65
" 9, 1917..	Californian Coast	63	67
" 11, 1917..	Lower Californian Coast	73	78
" 13, 1917..	Gulf of California	78	78
" 15, 1917..	Mexican Coast	82	87
" 17, 1917..	Gulf of Tehuantepec	74	81
" 19, 1917..	.....	80	81
" 21, 1917..	.....	77	86
" 23· 1917..	.....	80	84
" 25, 1917..	Balboa	.....	87
" 27, 1917..	Colon	.....	.....
" 29, 1917..	Between Colon and Jamaica	80	88
January 1, 1918..	Kingston, Jamaica	.....	78
" 4, 1918..	Between Cuba and Haiti	76	73
" 6, 1918..	Following Northerly course to Norfolk, Virginia...	68	73
" 8, 1918..		70	52
" 9, 1918..	Cape Hatteras	38	36

The readings of the electrical thermometers in the holds were taken every two or three days during the voyage between Portland and Norfolk. The temperature changes did not usually take place very quickly and therefore only a partial record of these observations is given in Tables 3-10. If the tables are studied in conjunction with Figs. 8-11 it will be found that the variations in temperature in any part of the hold can be quite closely followed.

TABLE 3.—Temperatures recorded on Line A.

No. 1 Northern, Highest Moisture. Average Moisture, 15 per cent.

No. 1 Northern, Average Moisture, 13·8 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	53·0	53·5	53·5	54·0	54·0	54·0	55·0	55·5	56·0	55·5	58·5	59·0	64·0
Dec. 7, 1917....	53·0	53·0	53·0	53·5	53·5	53·0	54·0	55·0	56·0	56·0	59·0	75·0	76·0
" 13, 1917....	53·5	53·5	54·0	54·5	54·0	54·0	54·5	55·0	56·0	55·5	61·5	86·5	85·0
" 17, 1917....	56·5	57·5	57·5	55·0	55·0	56·0	55·0	55·0	56·5	56·0	63·0	89·5	90·0
" 23, 1917....	60·0	61·5	61·0	58·0	58·0	59·0	56·5	56·0	56·5	56·0	66·0	90·5	94·5
" 29, 1917....	62·5	64·5	64·0	60·5	60·5	63·5	58·5	58·0	58·5	61·5	68·5	88·5	97·0
Jan. 6, 1918....	64·5	66·0	65·0	62·5	62·5	63·5	60·0	59·0	58·5	58·0	69·5	91·0	97·0
" 14, 1918....	62·5	63·5	63·0	63·0	63·0	63·5	63·0	61·5	60·0	60·0	69·5	67·5	80·5
" 17, 1918....	59·0	59·0	58·5	61·0	61·0	60·0	61·5	61·0	60·0	59·5	67·0	66·0	76·5
" 25, 1918....	53·5	55·0	52·5	56·0	55·5	54·5	58·5	59·0	59·5	59·5	64·0	63·0	73·0

REMARKS:—Thermometers Nos. 1-8 were embedded in the highest moisture wheat while Nos. 9-13 were in dryer wheat of the same grade. Thermometers Nos. 11–12–13 as shown in diagram No. 8 were close to the bulkhead and were affected by the high temperature in the stokehold which often reached 130°. In other parts of this layer no appreciable changes in temperature occurred until about December 17, and at no time were these increases sufficiently great to cause anxiety.

TABLE 4.—Temperatures recorded on Line B.

No. 1 Hard. Average Moisture, 14·0 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	55·5	56·0	54·5	55·0	55·0	55·5	55·5	55·5	54·5	54·5	54·5	55·0	56·0
Dec. 7, 1917....	55·5	55·5	54·0	55·0	55·0	55·0	55·0	55·0	54·0	54·0	54·0	54·0	55·0
" 13, 1917....	55·5	55·5	54·5	55·0	55·0	55·0	55·0	55·0	55·0	54·0	54·0	54·0	55·0
" 23, 1917....	55·5	56·0	56·5	55·0	55·0	55·0	55·5	55·0	58·0	55·5	55·5	55·0	55·0
" 29, 1917....	56·0	56·0	57·5	56·5	55·5	56·0	55·5	56·0	59·5	56·0	57·0	56·0	56·0
Jan. 6, 1918....	57·0	57·0	59·0	56·5	56·0	56·5	56·5	57·0	61·0	57·5	58·5	57·5	57·5
" 17, 1918....	58·0	58·5	57·0	57·0	56·5	57·0	57·0	57·5	58·5	57·0	59·5	59·5	59·0

REMARKS:—Thermometers Nos. 12-13 lay in parcel C. The temperatures recorded along this line remained practically constant throughout.

TABLE 5.—Temperatures recorded on Line C.

No. 2 Northern. Average Moisture, 13·2 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	56·5	56·5	57·0	57·0	57·5	57·0	57·0	56·0	56·5	56·5	56·0	62·0	69·0
Dec. 7, 1917....	56·5	56·5	57·0	57·0	57·0	57·0	57·0	57·0	56·5	56·5	56·5	64·0	73·0
" 13, 1917....	56·5	57·0	58·5	58·5	58·0	57·5	57·0	57·0	58·0	61·0	61·5	69·0	83·5
" 23, 1917....	57·0	57·0	57·0	57·0	57·5	57·0	57·0	57·0	57·0	57·0	58·0	76·5	94·5
" 29, 1917....	57·0	57·0	57·0	57·5	57·0	57·0	57·0	57·0	57·0	57·0	58·5	78·5	95·0
Jan. 6, 1918....	57·0	57·0	57·0	57·0	57·0	57·0	57·0	57·0	57·0	57·0	59·0	81·0	97·0
" 14, 1918....	56·5	57·5	57·0	57·0	57·0	57·0	57·0	57·0	57·0	57·0	59·5	77·0	84·0
" 24, 1918....	57·0	57·0	57·0	57·0	57·0	56·5	56·5	57·5	57·0	57·0	60·0	70·5	75·5

REMARKS:—The only appreciable changes in temperature along this line occurred near the stokehold bulkhead around thermometers No. 12 and No. 13.

TABLE 6.—Temperatures recorded on Line D.

No. 3 Northern. Average Moisture, 13·6 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	56·0	57·0	57·0	57·0	56·0	55·5	55·5	55·0	55·0	56·0	55·5	56·0	54·0
Dec. 7, 1917....	56·5	57·0	57·5	57·5	56·5	56·5	56·0	55·5	56·0	56·0	55·5	56·0	53·5
" 13, 1917....	56·5	57·5	57·5	57·5	56·0	56·0	56·5	56·0	56·0	56·5	56·0	56·0	54·0
" 23, 1917....	57·0	57·5	57·5	58·0	56·5	56·5	56·5	56·5	56·5	56·5	56·5	57·0	55·5
" 29, 1917....	56·5	57·0	57·5	58·0	57·0	56·5	56·5	56·0	56·5	56·5	56·5	56·5	56·5
Jan. 6, 1918....	56·5	57·0	57·5	58·5	56·5	56·5	56·5	56·5	56·5	56·5	56·5	57·0	58·0
" 17, 1918....	56·5	57·0	57·0	58·5	56·5	56·5	56·5	56·5	56·5	56·5	56·5	56·5	59·0

REMARKS:—No marked variations in temperature were indicated by the thermometers in this layer.

TABLE 7.—Temperatures recorded on Line F.

No. 1 Hard Highest Moisture. Average Moisture, 15 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	54·0	55·0	55·0	55·0	55·5	55·5	55·0	55·5	55·5	55·5	55·5	55·5	55·0
Dec. 9, 1917....	53·5	54·0	54·5	55·0	56·0	56·0	56·0	56·0	55·5	56·0	56·0	56·0	55·5
" 23, 1917....	57·0	55·5	56·0	56·0	56·5	56·0	56·0	56·5	56·0	56·5	56·5	56·5	55·5
" 29, 1917....	58·0	56·5	56·5	56·0	57·0	56·0	56·0	56·0	56·0	56·0	56·0	56·0	55·0
Jan. 6, 1918....	61·0	58·5	58·5	56·5	57·0	56·0	56·0	56·0	56·0	56·0	56·0	56·0	55·5
" 17, 1918....	60·5	60·0	60·0	57·5	56·5	56·0	56·0	56·5	56·0	56·0	56·0	56·5	56·0

REMARKS:—The first four thermometers along this line indicated slight increases in temperature; the rest showed practically no change whatever.

TABLE 8.—Temperatures recorded on Line E.

No. 1 Northern. Average Moisture, 13·8 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	52·0	52·5	53·0	55·0	55·5	56·0	56·0	57·0	56·5	57·0	57·0	56·0	57·0
Dec. 7, 1917....	51·0	51·0	52·0	53·0	54·5	55·0	55·5	57·0	56·0	56·5	56·5	56·5	56·5
" 13, 1917....	54·0	53·5	53·5	54·0	54·0	53·5	54·5	56·5	55·5	56·0	56·0	55·5	57·5
" 17, 1917....	57·5	57·9	56·5	55·5	55·0	55·0	56·0	54·5	55·5	55·5	55·5	57·0	61·0
" 23, 1917....	63·5	62·0	61·5	58·5	57·0	56·5	55·5	55·5	55·5	56·5	56·5	61·0	66·0
" 29, 1917....	68·0	67·0	66·0	63·0	61·5	61·0	58·5	57·0	57·0	59·0	58·5	65·0	70·5
Jan. 6, 1918....	69·5	69·0	68·5	66·0	66·5	65·5	62·5	60·0	60·5	62·5	62·0	69·5	74·0
" 14, 1918....	53·0	54·0	53·5	59·0	64·5	66·0	63·5	62·5	63·0	64·5	64·5	68·5	69·5
" 24, 1918....	43·0	44·0	44·0	47·0	53·0	63·0	61·5	63·0	63·0	63·0	63·5	62·0	58·5

TABLE 9.—Temperatures recorded on Line G.

No. 1 Northern. Average Moisture, 13·8 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	52·5	55·0	.....	56·0	56·5	56·5	57·0	55·0	56·0	52·5	50·5	50·5	56·0
Dec. 7, 1917....	52·5	53·5	.....	55·0	55·5	55·5	54·5	53·5	54·5	54·0	54·0	55·5	56·5
" 13, 1917....	56·0	54·5	.....	55·0	55·5	55·0	54·5	55·0	54·5	59·0	64·0	65·5	63·0
" 17, 1917....	61·5	56·5	.....	55·5	56·0	55·5	55·5	57·5	56·5	66·0	73·0	74·0	70·5
" 23, 1917....	66·5	60·0	.....	57·5	59·0	57·5	59·0	63·0	61·0	74·0	79·0	80·0	77·0
" 29, 1917....	72·0	64·5	.....	60·0	60·0	61·5	64·0	69·0	66·0	78·0	81·0	82·5	80·0
Jan. 6, 1918....	74·0	68·0	.....	63·5	64·5	67·0	70·5	74·5	71·5	80·0	79·0	80·0	83·0
" 14, 1918....	45·5	58·0	.....	63·0	65·0	65·5	68·0	68·5	68·0	57·0	45·5	45·5	66·5
" 24, 1918....	39·0	49·0	.....	52·0	59·0	61·5	61·0	57·5	60·0	47·0	40·0	40·0	55·0

REMARKS:—The thermometers along both the lines E and G showed somewhat wide fluctuations in temperature. They were quite close to the top of the hold and quickly responded to changes in the outside temperature.

TABLE 10.—Temperatures recorded on Line X.

No. 1 Northern. Average Moisture, 13·8 per cent.

Thermometer No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nov. 27, 1917....	62·0	63·0	61·0	61·0	61·0	62·5	.....	61·0	61·0	61·5	64·5	67·0	78·5
Dec. 7, 1917....	57·5	63·5	62·0	61·0	61·5	63·0	.....	61·5	61·5	63·0	69·0	70·0	83·0
" 13, 1917....	62·5	65·0	62·5	62·5	62·5	64·5	.....	62·5	62·5	66·5	77·5	81·5	92·0
" 17, 1917....	68·5	69·5	64·5	65·0	65·0	66·5	.....	65·0	64·5	70·0	82·5	85·5	98·0
" 23, 1917....	72·0	74·0	67·5	68·5	68·5	71·0	.....	68·5	68·0	74·0	85·0	87·5	98·5
" 29, 1917....	75·0	78·0	70·5	72·0	72·5	74·5	.....	73·0	72·0	78·0	87·5	90·5	101·5
Jan. 6, 1918....	76·0	80·0	73·0	75·0	76·0	78·0	.....	76·0	75·5	81·5	89·0	90·0	98·5
" 17, 1918....	62·0	68·0	68·0	67·5	68·0	69·5	.....	68·0	69·5	65·5	62·0	61·0	71·0
" 24, 1918....	57·0	62·5	68·0	....	62·5	64·0	.....	63·0	65·0	60·5	59·0	57·5	68·0

REMARKS:—Thermometers 1–10 lay in the wheat near propeller shaft tunnel while Nos. 11–13 were in the air close to the engine room bulkhead. A steady increase in temperature took place until the ship's arrival at Norfolk.

Fig. 12 illustrates the variations in temperature shown by four of the thermometers situated in different parts of the hold.

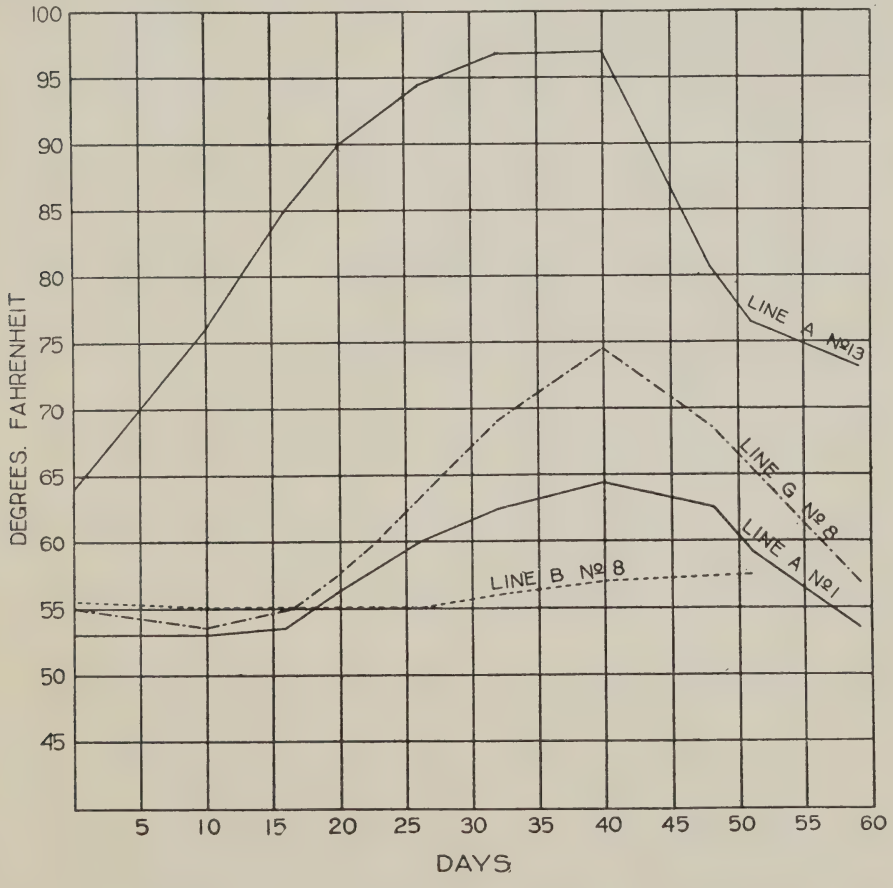

Fig. 12. Curves illustrating variations in temperature shown by theremometers Nos. 1 and 13 on line A, No. 8 on line B and No. 8 on line G.

The ship docked in London on 16th of February and the discharging of the grain was started two days later. An attempt was made to take the temperatures in the holds before discharging but this was found to be impossible. The protection of the switches had not been sufficient for the very rough weather which was experienced, and the metal contacts had corroded to some slight extent, so that when the battery was connected, short circuits were set up and it was impossible to obtain an accurate balance on the galvanometer.

Careful examination of the grain at the time of unloading showed that a certain amount of damage had occurred, the extent and location of which is shown in the following diagrams in which the darkened portion indicates the heated grain.

Layer A.—In layer A the wheat was found to be heating in two places close to the stokehold bulkhead. This wheat was slightly warm and very musty, but the amount so affected was quite small—probably not more than about three bushels altogether. In addition a few pounds of wheat which was wet, soft and discoloured had caked here and there to the floor of the hold in the vicinity of the bulkhead. Except in these places the floor was quite clean and dry, and the rest of the wheat in this parcel was perfectly sound.

Layer B.—Heating wheat was found in this layer immediately above the warm spots in Layer A. The amount of damaged grain was rather more than in the bottom parcel, but it was still quite small. There was no other damage in this layer.

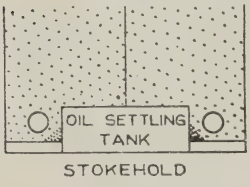

Fig. 13. Diagram showing damaged grain in layer A.

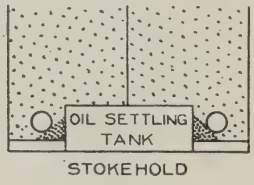

Fig. 14. Diagram showing damaged grain in layer B.

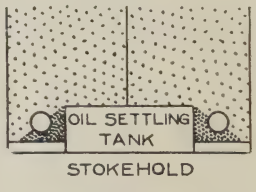

Fig. 15. Diagram showing damaged grain in layer C.

Layer C.—Except for a few bushels of hot wheat close to the stokehold bulkhead this parcel of grain arrived in good condition.

Layer D.—The quantity of wheat found to be heating in this parcel was considerably more than in Layer C, probably amounting altogether to about sixty bushels. The position of the damaged grain was the same as in the lower layers.

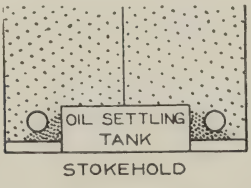

Fig. 16. Diagram showing damaged grain in layer D.

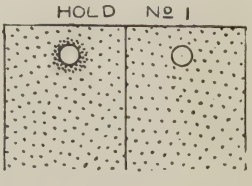

Fig. 17. Diagram showing damaged grain in layer F.

Layer F.—With the exception of about two bushels of slightly warm wheat under the forward ventilator on the port side, this parcel arrived in perfectly sound condition.

Layer E.—It was in this parcel that the damage was most extensive. A body of grain occupying the space between the sides of the ship and the oil settling tank was found to be heating and musty. In some places the wheat was warm five feet away from the bulkhead, and to the full depth of the layer. Probably 700-800 bushels were affected altogether, some of it being very warm, covered with fungi growth, and caked so badly that it was difficult to break down, while in other places it was only just warm and held together very loosely. All the heating wheat which has been described up to the present was mixed up and worked in with the sound wheat during the unloading. The cargo superintendent apparently considered that the damage was not sufficient to make the separate treatment of this grain necessary, and it is for this reason that more accurate information cannot be reported with regard to the weight of grain which arrived out of condition.

Underneath the port ventilator at the forward end of the hold, a quantity of grain weighing about four bushels was found to be badly heating in this parcel. There seems to be little doubt that the cause of this damage was the drainage of water down the ventilator. This wheat was not mixed up with the sound grain.

Along the sides of the ship in the after half of the hold there was a thin layer of very wet, sour and discoloured grain which near the surface had sprouted badly. The bad condition of this wheat was attributed to "sweat" damage. All the grain so affected was kept separate from the main bulk of the parcel.

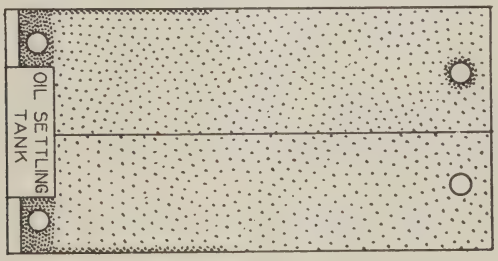

Fig. 18. Diagram showing damaged grain in layer E.

Layer X.—In this layer very small quantities of soft, wet wheat had caked in places to the floor of the hold. This damage was probably caused partly by "sweat" and partly by the leakage of small amounts of water around the rivets in the ship's side.

Layer Y.—This parcel was discharged in good condition except for a little wheat which had caked round the side as in Layer X, and small quantities which were heating and musty on each side of the propeller shaft tunnel immediately under the mast. This latter damage was evidently caused by the leakage of sea water around the mast.

The damaged grain from layers X and Y, together with that from under the forward ventilator and the " sweat " damaged grain in layer E, was weighed up apart from the rest of the cargo, the total quantity being about 160 bushels. This was the only damage reported by the cargo superintendents, and amounted to less than 0·2 per cent.* But the total quantity of damaged grain is increased by probably more than 800 bushels if the more or less injured grain be taken into account. As far as the present shipment is concerned, this damage is perhaps of little commercial interest, since the wheat affected by it was mixed with the sound grain when the usual practice was followed during the discharging. It will indicate, however, where trouble may be expected in the case of future shipments unless certain precautions are taken.

While the reported damage was evidently due to " sweat " or the admission of water into the hold, the cause of the heating near the stokehold bulkhead is not quite so clear. As will be seen from Figure 19 the heating took place under the ventilators, down which a little water may have dripped during and after the loading. Tests on samples of heating wheat from layer C showed

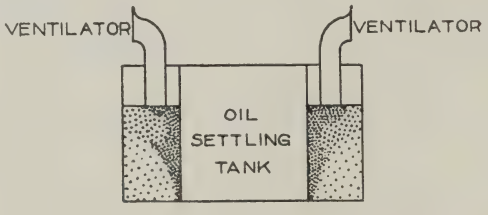

Fig. 19. Section through heating wheat near stokehold bulkhead.

15·2 and 15·7 per cent of moisture while a sample from layer E, contained as high as 21 per cent of moisture. These percentages do not however, necessarily indicate the admission of water into the hold, since the chemical changes due to respiration, which is very rapid in warm grain, always result in an increase in the proportion of water present. But whether the cause of the heating was the drainage of some water from the outside, or whether the moisture content of the wheat as loaded was dangerously high for the conditions in that part of the ship, there is no doubt whatever that the temperatures close to this bulkhead were altogether too high for safety.

During the discharging of the grain, average samples were collected from some of the parcels. These samples were tested in the laboratory for moisture and the results obtained, which are given in Table 11, show that no appreciable changes in moisture content occurred during transit.

*See Appendix 2.

TABLE 11.—Comparison of the moisture content of certain parcels of wheat sampled during loading and discharging.

Parcel.	Sampled at Loading. Per cent.	Sampled at discharging. Per cent.
B	14·0	14·1
E	13·8	13·7
Y	15·0	14·7
C	13·2	13·1
D	13·6	13·5

When the weight of wheat which was discharged is compared with the amounts loaded, it will be seen that the loss which took place during handling and transportation was not excessive.

TABLE 12.—Comparison of quantities of wheat loaded and discharged.

Parcel.	Weight loaded. bushels.	Weight discharged. bushels.
F	5,907	6,115
B	9,258	9,168
A	9,619	9,548
E	42,482	42,175
Y	4,062	3,993
C	14,559	14,459
D	13,322	13,375
	99,209	98,833

On the whole the loss is less than 0·4 per cent.

CONCLUSIONS

The results of the investigations in connection with this shipment indicate that if certain precautions are taken wheat may be carried to Europe via the Panama Canal without damage. The following recommendations are therefore made.

(1) Only wheat which is quite sound in every way should be shipped by this route; it should be carefully tested for moisture and any lots containing an excessive amount should not be loaded into the vessels. It has not been possible to determine just how much moisture the grain may safely carry, but until some limit is definitely set, a moisture content of more than 14·5 per cent should be regarded as dangerous.

(2) The temperatures recorded by the thermometers against the false bulkheads near the engine room and stokehold are evidently too high for safety, and an unventilated air space of nine to twelve inches cannot then be considered sufficient protection. It is recommended therefore, that when it is necessary to stow grain close to the engine room or stokehold, these spaces be either ventilated or extended. The records clearly show that it was only in these portions of the holds and close to the propeller shaft tunnel that dangerously high temperatures occurred. The conditions will vary in different ships but the adequate protection of the grain cargo in these parts of any vessel is one of the most essential conditions for its safe transportation.

APPENDIX 1

While in Portland, Oregon, some trouble was experienced in obtaining satisfactory temperature readings with certain lines of thermometers. It was noticed that on breaking the circuit by releasing the button on the instrument the galvanometer needle swung sharply over to one side and only returned to the centre very slowly. The temperatures then recorded were from 2° to 5° low. After taking the switches apart and thoroughly washing with gasoline the trouble disappeared. The weather had been very wet during and after the installation of the thermometers and it seems probable that the moisture, together with small quantities of salts in the soldering grease, had caused slight short circuits through the switches. It is therefore advisable in work of this nature to use pure rosin paste when soldering and to take great precautions to see that the switches do not get wet.

APPENDIX 2

The following extract from the report of the Superintendent who supervised the discharge of the wheat cargo may be of interest. "With regard to the condition of the various shipments, we are glad to say, that the condition of all parcels was good throughout, with the exception of about 20 qrs. of damaged wheat ex parcel of No. 1 Northern, which damage in our opinion has been caused through sweat."

(3) Excepting in the neighbourhood of the stokehold bulkhead the only damage which occurred in this shipment was due to "sweat" or the admission of water. The importance of keeping the grain dry during loading and of preventing the subsequent entrance of water into the holds hardly needs to be emphasized. If the Panama Canal route is used to any extent for this trade most of the shipments will probably be made from Vancouver during the rainy season, and it will therefore be necessary to take steps to prevent water from dripping down the hatches and ventilators during loading. In addition to this the ventilators should be covered during rough or wet weather at sea, and no wet cargo of any sort should be stowed in the same hold as the grain.

(4) One feature which was against the present shipment was the length of the voyage, the grain being in the vessel three and a half months altogether. When heating once starts in a body of grain it proceeds at an accelerating rate so that the length of time the wheat is in transit may have a great deal of influence on the quantity which arrives out of condition, and the extent of the damage. If possible then the use of slow ships in this trade should be avoided.

The conditions to which the grain is subjected in transit by this route are much more severe than those experienced by Atlantic shipments. The temperatures are higher and the voyage much longer, but it is believed that if it is possible to observe the above precautions, there will be little difficulty in carrying wheat cargoes safely. The results of this experiment certainly seem to justify further trials.